POSITION PAPER

THE LIFE CYCLE METHODOLOGY FOR STEEL CONSTRUCTION

Fondazione Promozione Acciaio

Fondazione Promozione Acciaio

Fondazione Promozione Acciaio - FPA - (https://www.promozioneacciaio.it/) is a non-profit organization established in 2005, that operates as a cultural institution dedicated to promoting steel construction and infrastructure development in Italy.

FPA actively contributes to the innovation and competitiveness of the construction industry, by disseminating and enhancing the design and construction technology aspects that distinguish the solutions steelwork construction. FPA engages in extensive editorial, communication and marketing activities, technical support and professional training. Moreover, FPA represents the steel construction supply chain in the institutional and technical standardization forums at national and CEN levels, collaborates with public and private bodies in the construction sector, raising awareness among clients about the benefits of steel and the construction system through the dissemination of knowledge. 5 Technical and Scientific Commissions operate within FPA: Seismic, Fire, Standards, Infrastructure and Sustainability.

FPA Sustainability Commission

The Sustainability Commission identifies opportunities and challenges in the construction sector, with a focus on the environmental costs. It promotes sustainable and intelligent construction products and solutions, designed and built taking into consideration the environment and people, an expression of the ability to consider the entire life cycle of buildings with a view to a true circular economy.

The Commission educates on proper life cycle assessments of projects. Steel, due to its circular nature, plays an important role in creating truly sustainable buildings and infrastructure. Flexibility, adaptability, durability, reusability, and complete recyclability are qualities of steel construction and key pillars of ecological transition.

The Commission organizes seminars and conferences and elaborates technical documents guiding designers toward appropriate construction choices, both for new constructions and for interventions in existing buildings. It also raises awareness among institutions and investors and participates in European technical discussions on the drafting of national and CEN regulations.

Introduction

In today's construction industry, environmental sustainability and responsible resource management are crucial issues. In 2019, the European Council set a target for the EU to achieve climate neutrality by 2050, central to the European Green Deal and in line with the Paris Agreement signed in 2015.
Within the EU, 40% of energy consumption is covered by fossil fuels and buildings account for 36% of CO2 emissions throughout their life cycles.
The carbon footprint of a building starts well before its actual use, beginning with the extraction and transport of building materials, followed by with the transformation into finished products, construction, demolition and even beyond as resulting waste must be reused, recycled or disposed of. Given these significant impacts, the construction sector has immense potential for mitigating climate change and adapting to new environmental challenges. One keyway to address these challenges is to apply "Life Cycle Assessment" (LCA) throughout a building's life, from construction to demolition. This Position Paper explores how the application of LCA can improve efficiency and sustainability in the construction sector, focusing on the use of steel as a main material and highlighting its benefits, started to contribute to the decarbonization target. It also highlights the European steel industry's ongoing efforts to meet decarbonization goals. The steel industry is undergoing significant technological acceleration driven by digitization, process efficiency, artificial intelligence, and the challenges of sustainable production and the circular economy.
While scrap-based production, a well-established practice, will benefit from the increasing availability of renewable energy sources and higher scrap utilization rates, ore-based production will rely on technological developments and the use of hydrogen and alternative reagents to replace traditional carbon coke (DRI/HBI), compensating for the potential imbalance between scrap supply and demand. The use of natural gas or hydrogen as a reducing agent will further reduce the carbon footprint of steel production. The document also aims to give a strong and authoritative message from the entire Italian steel construction supply chain, which has been underrepresented in terms of communicating its environmental best practices, by emphasizing recovery, reuse and recycling as key elements supporting the ecological transition to which the entire industry is called to contribute. Through a detailed analysis of the steel structure construction process, this Position Paper analyzes all stages of the construction value chain, clarifying the benefits that can result from adopting a model based on circularity, materials quality and industrialized construction technologies that consider environmental and social benefits throughout the entire life cycle of buildings.

Carpentry buildings: circular economy, production cycle and recyclability

Italy is the 2nd largest producer and consumer of steel in the EU, just behind Germany. Despite the stigma of being one of the highest-emission industries, it is important to clarify that nowadays, direct and indirect emissions from the Italian steel industry account for only 4.5% of Italy's total emissions. In fact, the carbon footprint of domestic production of a ton of steel has decreased by 60% since 1990 [8]. The industry is rapidly decarbonizing, with 35% of the industry's investment is in improving environmental performance and occupational health and safety. Steel, unlike other materials, can be recycled an infinite number of times without loss of its original properties (up-cycling), and Italy holds the record as the first country within the EU for steel production from recycled scrap metal: 85% of national steel production is from electric arc furnace (emissions from this process come mainly from the electricity used). The Italian steel industry also records a reduction of more than 33% in total energy consumption per ton of steel since 2000, making it the most energy-efficient in the EU, with specific consumption values 38% lower than the European average. Steel is, therefore, thus emerges as a key material for the transition to a truly circular economic model aimed at reducing the consumption of natural resources, focusing on the principles of reusing and recycling existing materials and products for as long as possible (reduce, reuse, recycle) [8].

When examining the next phase of product transformation, the circular economy within a steel construction company operates in two macro areas: 1. the management of incoming materials and 2. the management of waste during processing.

1. All construction steel purchased from the steel mill or distributors (long products such as beams, hollow sections and merchant rolled products; flat products such as mill plate and coils; etc.) must be of certified origin with CE marking and accompanied, where required, by clear Environmental Product Declarations (EPDs), including reports of the scrap content in the product.
2. The transformation of the products into finished structural elements in a steel construction plant is highly efficient, generating a very small amount of waste virtuous, as it gives rise to a very small amount of waste materials, most of which the cycle intended for recovery is reintroduced into the recovery cycle, without downgrading.

Looking at the market and related numbers these testify to what has been claimed since a modern Italian metal carpentry company with a turnover of about 130 million euros and 250 employees, out of a total of 45 orders processed in 2022.
The company reported:

- 12,500 tons of processed construction steel.
- 471 tons or 3.77% of construction steel resulting as scrap from processing CER 170405 [4] (ferrous scrap).
- percentage of processing waste recovered as scrap and fed back into the steel production cycle equal to 100%.
- Tons of waste from Iron Powder CER 120102 [4] (resulting from grinding, cutting and drilling activities): 10 Tons.
- Tons of waste arising from abrasive discs EWC 120120 [4]: 1.3 Tons.
- Tons of waste from aluminum containers containing pressurized gas EWC 150111 [4] (used for weld seam cleaning): 70 Tons.
- Tons of mixed municipal waste (energy recovery through municipal waste-to-energy - waste-to-energy): 15 Tons.
- the entirety of the paper and cardboard resulting from the packaging of the welding materials (wire) are taken back by the municipalized company and fully fed into the recycling system.

Quantifying the tons of waste that are not directly sent for recovery without further treatment results in a percentage by weight of tons produced of 0.13 percent.

Sustainable construction is a critical issue, both locally and internationally. When selecting materials for a project, it is essential to perform a comprehensive life cycle analysis. The embodied energy in steel is significantly reduced by its ability to be endlessly recycled, but this is only part of the picture. The durability and recyclability aspects of the material itself must also be considered. Steel is a low- carbon material and can be recycled an infinite number of times without any degradation of the product, what is instead known as "down cycling," which is when a material after recycling becomes a by-product.

Steel therefore meets the key principles of the Circular Economy because:

- It is used in designs that minimize the amount of material required to provide the desired function.
- It is produced in an environmentally and energy sustainable manner, i.e., with a low life cycle impact, as determined by product-specific EPDs.
- It is used in low- or zero-carbon construction techniques with maximum efficiency and minimum waste on site: structural steelwork, industrialized and off-site construction.
- Promotes future uses after end-of-life, maximizing during the life cycle the potential for maintenance, repair, and renovation, providing flexibility and adaptation for future changes of use, providing for disassembly and deconstruction to facilitate reuse or sending for recycling through easy separation from other building components.

Sustainability and Durability: key features of steel

The sustainability of a material is linked to its durability and its potential for reuse or recycling. For steel, sustainability means ensuring that its strength and versatility are preserved over time with minimal environmental, social and economic impacts.
Steel outperforms alternatives like concrete and wood, thanks to corrosion protection systems, that maintain its properties and structural integrity, depending on the installation environment and required durability. Various treatments are available to protect steel from oxidation, ensuring that it retains its properties, can be recycled nearly 100% and in cases where regulations permit, steel profiles can also be reused at the end of a structure's life for the same or different applications.
Throughout a structure's entire lifespan, steel benefits from corrosion-resistant treatments that increase the durability of the products and reduce the need for frequent maintenance. This not only saves environmental and economic resources but also minimizes the need for inspections required to ensure the safety of critical infrastructures, such as public buildings, bridges and viaducts, production facilities and other structures with economic or social significance.
For steel construction, current regulations guide the designer in selecting the appropriate protective treatment.
For example, the CE marking for steel products follows the UNI EN 1090 standard, which allows for the use of weather-resistant steel or the application of coatings such as hot-dip galvanizing, painting, or a combination of both. The evaluation of steel durability depends on the characteristics and reliability of each of these anti-corrosion methods, as summarized in Table 1.

Table 1. Durability comparison of anti-corrosion methods for steel. The maximum achievable durability is estimated up to the first maintenance and depends on the exposure environment.

Treatment	Standards Specifications	Performance Evaluation	Maximum achievable service life without extraordinary maintenance
Hot-dip galvanizing	UNI EN ISO 1461	UNI EN ISO 14713-1 UNI EN ISO 9223 UNI EN ISO 9224	100 years, depending on the exposure environment.
Painting	UNI EN ISO 12944-5	UNI EN ISO 12944-5	More than 25 years depending on applied cycles and exposure environment
Duplex systems (painting on hot-dip galvanizing)	UNI EN ISO 1461 UNI EN ISO 12944-5 UN EN 13438	UNI EN ISO 12944-5 UNI EN ISO 14713-1	$D_{D.sys.} = (1{,}2 \div 2{,}5\ (D_{Zinc.} + D_{Vern.})$ Protection lasts longer than the sum of the individual durations
Weather resistant steel (ex corten)	UNI EN 10025-5	UNI EN 10025-5 Allegato C	Up to 25/30 years in conditions specified in UNI EN 10025-5 Annex C.
Pre-galvanized sheets	UNI EN 10346	UNI EN ISO 9223 UNI EN ISO 9224	Up to 60 years depending on the thickness of coating applied

For steel, various treatments are available that can cover the entire service life of structures, in line with NTC 2018 requirements (50 years for constructions for which ordinary performance is required such as common public and private civil works, and 100 years in the case of high performance such as buildings or infrastructure of strategic interest).
Since steel durability depends on the applied anti-corrosion treatment, it's crucial to know the Life Cycle Assessment (LCA) data for each method to evaluate overall sustainability.

It is important to prioritize for anti-corrosion systems whose environmental impacts are known, such as those certified through EPDs. Both corporate and sectoral EPD environmental certifications are available in this regard, and the hot dip galvanizing industry has an LCI data inventory and an EPD on European average performance [7].
Steel protection involves relative environmental and energy costs, but the increased durability distributes the total impacts over the structure's service life. This enhances overall sustainability by reducing the need for major maintenance interventions and lowering global emissions.

Criteri Ambientali Minimi (CAM) and the steel supply chain: benefits and limitations

The Criteri Ambientali Minimi (CAM) [5] defines the minimum environmental criteria that must be respected during various phases of procurement. The goal is to identify the best design solution, product, or service based on environmental performance throughout its life cycle. Table 2 highlights some considerations about CAM that emerged across the steel supply chain, from production to final installation.

Table 2. Comparison table between what is reported on steel in the CAM decree and what emerged from the dialogue with the supply chain.

	CAM – DM 4.12.2022	BENEFITS AND LIMITATIONS
% of material recycled or recovered	For structural uses, steel must be produced with a minimum content of recovered or recycled material, or by-products, with the following minimum levels: - steel from electric furnace: unalloyed steel, 75%; alloyed steel 60% - steel from integral cycle 12%. For non-structural uses, steel produced with a minimum content of recycled or recovered materials or by-products shall be used: - electric furnace steel 65%; alloyed steel: 60% - steel from integral cycle 12%.	Recycled content is a non-exhaustive indicator of the sustainability of a product or project. To decarbonize the manufacturing and construction sector, CO_2 equivalent emissions must be reduced. Higher recycled content can contribute to a lower environmental impact, but it cannot be the only strategy. In the specific requirement of the CAM document, the indicator is a minimum criterion, while the LCA calculation methodology, described in the technical standards EN15804 (building products) and EN15978 (buildings), is referred to in the award criteria related to "Methodologies for optimizing design solutions for sustainability." Only through an LCA analysis is it possible to make design choices aimed at reducing emissions.
Product Declarations	The recycled or recovered matter or by-product content must be demonstrated through one of the following options: - Type III Environmental Product Declaration (EPD). - ReMade in Italy certification. - Other product certifications issued by a conformity assessment body.	EPD-Environmental Product Declaration certification (which must also comply with ISO 14025 and EN 15804 for construction products) is a voluntary document for reporting on the environmental impacts of a product or service based on LCA analyses that define the consumption of resources (materials, water and energy) and impacts on the surrounding environment at various stages of the product's life cycle. The preparation of such a certification requires validation by an accredited external body.
Methodologies for optimizing design solutions for sustainability (LCA and LCC)	A rewarding score is given to the economic operator who submits a project with better environmental and economic performance, compared to the project. The improvement must be validated by an LCA study according to UNI EN 15643 and UNI EN 15978. The score is proportional to the construction elements considered, or it is awarded proportionally to the improvement in the environmental profile of the project.	To date, life cycle analysis (LCA) is the only standardized tool for assessing environmental impacts (ISO 14040 series standards), and in other European regulations it is also the key reporting tool. In several European countries LCA is mandatory for new designs, unlike Italy where it is only a rewarding criterion.
Optimization of design solutions: Transportation distance of construction products	A rewarding score is given to the economic operator who commits to procure at least 60 % by weight of the total construction products at a maximum distance of 150 km from the site of use. The construction products must meet the technical requirements specified in the project documents. This distance is calculated between the site of manufacture (i.e., the production site and not a material storage or resale site) and the construction site. N.B. This award criterion cannot be combined with the previous LCA criterion.	While not a binding criterion, placing more emphasis on reducing CO2 emissions solely related to transport can be simplistic and misleading. The greatest risk is related to the erroneous assumption that transport-related CO2 is always the most significant factor in calculating total emissions, potentially penalizing many construction materials. Transportation represents only one indicator of impact in the life cycle of any material, a criterion that is easy to achieve but not comparable in terms of effort, expertise and skills to an LCA analysis.

Life Cycle Assessment: a tool for designing and assessing Environmental Sustainability

Despite the attempt to outline a clear scenario for construction products, particularly their sustainability characteristics through CAM, significant difficulties still arise at different levels and depending on the stakeholders involved. At the European and national levels, current regulations and standards apply throughout the design, production, and supply phases, all the way to the construction site.

1. Design

In addition to mandatory regulations, the market increasingly demands voluntary certification protocols such as LEED, WELL, BREEAM, WiredScore to name the most common ones. As a result, design solutions are evolving toward high environmental standards, which are also increasingly demanded by both public and private investors/contractors. The common goal must be to evaluate how and what leads to the achievement of environmental goals and how these should be promoted without overlooking any design and production stage. This requires focusing primarily on the choice of materials that align with a circular approach, thanks to their recyclability and extended life cycle, but also the construction technology itself, which must be flexible, easy to assemble, and disassemblable for future reuse.

2. Production

Today, manufacturers are not required by law to provide product certifications such as EPDs to demonstrate the environmental impacts of construction products. However, in recent years, European steel manufacturers have made major environmental investments, obtaining product certifications that verify the impacts of their products in terms of emissions and recycled content.
Furthermore, the market increasingly regulates the use of these products in various applications. Numerous regulations and directives are available to national and international organizations in Europe, including the European Green Deal; European Circular Economy Action Plan; EU Level(s); and EU Carbon Border Tax.
Additionally, At the same time, there are numerous specific regulations currently in force, including:

- voluntary green building schemes (BREEAM, LEED, DGNB, WELL, etc.).
- products and buildings LCA (e.g. Netherlands, Belgium, Norway, Sweden, Indonesia.
- (Green) Public Procurement, e.g. Sweden (Trafikverket, Boverket) and Italy (purchases made by Public Administration).
- Supply chain management (e.g., EcoVadis, SEDEX).
- green bonds (e.g., through ISO standards).

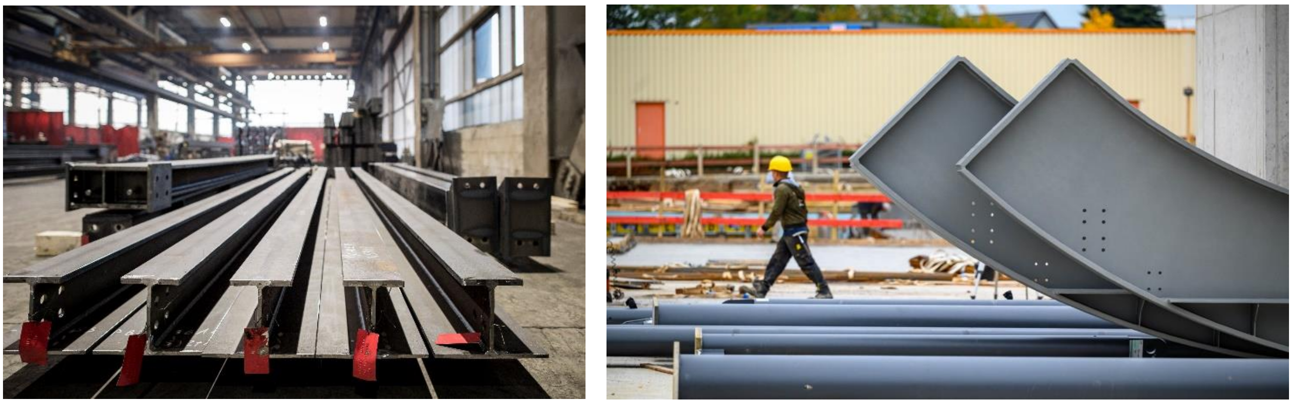

Figure 1. Carpentry structures at PICHLER projects workshop (photo left: Alex Filz) and BORA HQ construction site (photo right: Bora).

3. Supply

Steel product suppliers, like other actors in the supply chain, act as intermediaries between manufacturers and designers. They are available to help designers to select the best product for their design needs in terms of the environmental sustainability performance of steel products by sharing data made available by manufacturers.
Generally, information is typically provided on recycled material content and the amount of CO2 emissions per ton of steel. When the information requested by the designer cannot be found through product documentation, an ongoing dialogue between suppliers and manufacturers is necessary to find the missing data and ensure that designers make informed choices.
To facilitate the process, greater investment can be made in supplier qualifications, conducting a quantitative and qualitative assessment of their technical and managerial capabilities, performance quality, economic reliability, compliance with ethical requirements, environmental and biodiversity protection and preservation. This assessment should also consider whether they have the necessary policies and certifications. In this context, some European countries, in line with what has also been recorded and presented in this paper at the Italian level, are accelerating their efforts to meet climate change commitments and regulations [10].

LCA analysis for building materials: focus on the properties of steel

Among the available tools and methodologies to evaluate the environmental, economic, and social performance of materials and consumer products (including their impact on climate change and natural resources), Life Cycle Assessment (LCA) provides a holistic approach that considers the potential impacts of all stages of manufacturing, product use, and end-of-life (reuse, recycling, or disposal). A life cycle approach is currently the only recognized method of assessing a product's environmental impact. It is also the best way to help society make informed decisions about material use and their economic importance [11].

Building-level LCA analyses are becoming the tool used by various regulations to assess the embodied carbon in buildings. LCA can be compared to any other engineering design tool that helps select suitable and less impactful building materials, evaluate construction techniques, compare different structural solutions, and consider the building's end-of-life. In the construction sector, the life-cycle approach can lead to significant benefits [12]: the possibility of reducing impacts on the environment by identifying potentially less impactful alternatives, for both renovation projects and new construction interventions, in terms of materials selection and construction systems, and the possibility of earning scores in certification schemes (LEED v4, BREAM, etc.).

To comply with decarbonization regulations, many governments are making the LCA approach mandatory. This methodology can quantify both operational emissions and the impact of materials and construction processes (so-called Scope 3 emissions) required to meet many corporate environmental policies.

Box 1. Definition and structure of Life Cycle Assessment.

LCA, Life Cycle Assessment, is a method that evaluates the set of interactions a product or service has with the environment, considering its entire life cycle, which includes the stages of: pre-production (including material extraction and production); production; distribution; use-reuse and maintenance; recycling; and final disposal. The LCA procedure is standardized internationally by ISO 14040 and 14044.

To properly assess the environmental impacts of a building and its structural solution, it is necessary to calculate the environmental impacts of all the products used to build it. This is why reliable materials data, particularly in the form of Environmental Product Declarations (EPDs), are so crucial for ensuring the quality of the building Life Cycle Assessment (LCA).

One of the main goals of performing a building LCA is to reduce the environmental impacts of the project. One of the easiest ways to achieve this goal is to select materials that perform better in terms of reduced carbon footprint, have a recycled content (and thus less raw material use), are produced with clean energy sources, and have a lower frequency of replacement than other materials, being characterized by longer durability.

Steel presents a combination of properties that make it suitable for sustainable design and must be considered in the decision-making process. These properties include (i) chemical, metallurgical, and mechanical properties, (ii) corrosion resistance properties, (iii) fire resistance properties, (iv) recyclability, (v) long service life, (vi) maintenance requirements, (vii) hygiene requirements, (viii) aesthetics (ix) and low carbon footprint manufacturing.

Steel can be recycled without any loss of quality, as metal bonds are restored during resolidification. Steel produced by recycling is a premium material that retains its original performance properties, even after multiple recycling cycles. This allows us to use it repeatedly for the same application making it a true permanent resource but also to build adaptable and flexible structures.

On the other hand, the performance characteristics of most nonmetallic materials, excluding glass, degrade after recycling and become a subproduct. This results in significant benefits, quantified within modules C and D of the LCA analysis. In addition to the production cycle, it is essential to consider what happens downstream of production with a "cradle-to-grave" or "cradle-to-cradle" approach. Otherwise, sustainability results might be misleading and incomparable. This could happen because end-of-life assumptions strongly condition results and are a function of multiple parameters, some based on estimates and not empirically calculable. To compare materials or structural solutions, LCA analysis must be extended to the entire life cycle of the building product (including all modules shown in Figure 2), using reliable and homogeneous inventory data and equivalent functional units. The functional unit serves to normalize the results on a common basis. It refers to a unique amount of a product or product system based on its performance in its final use, and it is defined by ISO 14040. This definition is crucial when comparing solutions or products to ensure that the selected units are functionally equivalent. Functional units, therefore, change as the purpose of the LCA study changes. For complex systems such as buildings, the functional unit becomes a "functional equivalent" (EN 15978:2011 standard), meaning that the comparison can only be made between structures or systems that are functionally equivalent. It is not representative to compare structural elements or buildings that do not serve the same functions. For example, it is not representative to compare a steel beam of "x" meters with a beam of another material of the same length because these two structural elements, which apparently have the same function, are not necessarily an equivalent functional unit.

One of the biggest challenges in performing LCA is the availability of inventory data. Currently, the only useful tool is EPDs, which are based on an LCA analysis of products and present the results as a function of environmental indicators, such as CO2 emitted or GWP- Global Warming Potential per declared unit of product (e.g., Tons). It's important to note that EPDs, even for the same product category, are often not comparable because they use different calculation assumptions, calculation methods and functional units. For building materials, LCA often refers to "declared units" which is the quantity of product considered in the analysis, typically expressed in kg or m3. Therefore, it does not make sense to compare the data contained in an EPD to draw conclusions about the sustainability of materials in an absolute sense.

Instead, a complete LCA analysis based on an appropriate functional unit should always be done. Shifting the focus to the built environment, the largest emissions are associated with operational carbon (energy consumption), and in second place is carbon embedded in building materials. However, energy efficiency and clean energy will dramatically reduce operational carbon, while, embodied carbon, over time, will be the main source of CO2 emissions in the construction sector. That is why building materials are critical in the decarbonization process.

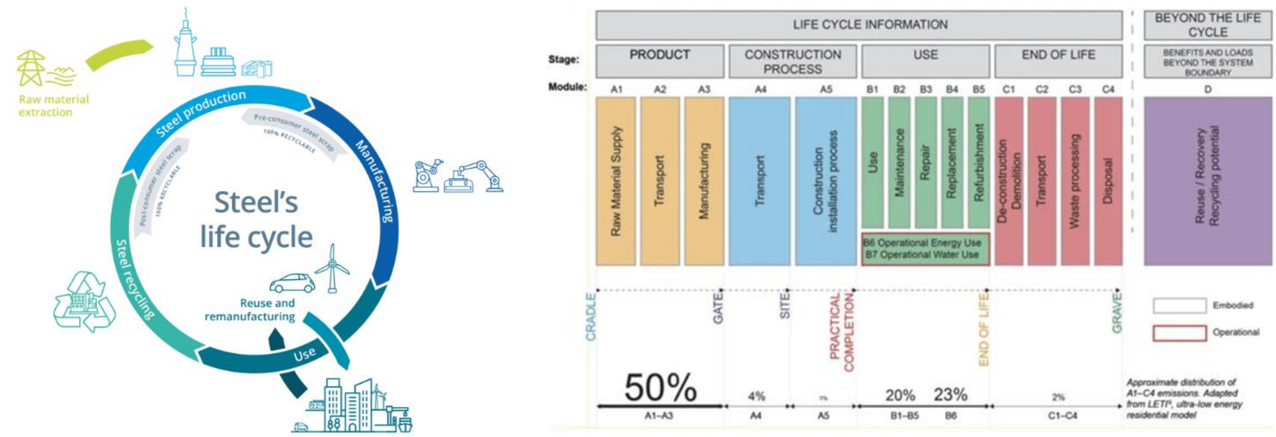

Figure 2. Steel life cycle [10] (left) vs building LCA (right).

It is not always easy, at the design stage, to find the "most sustainable" alternative among different options, since there are no solutions that are more sustainable than others, especially in the construction sector. The difficulty lies in having to evaluate products and solutions on a case-by-case basis and having to make calculation assumptions that are as accurate as possible. Designers must be able to compare different solutions and environmental impacts in a simple but consistent way, to choose the most appropriate one for their project. In this process, LCA is certainly a valid and scientifically recognized tool for creating more aware and efficient designs that generate value and move toward sustainability.

The basic rule to keep in mind is that to reduce emissions, it is essential to start by optimizing material use. The approach to sustainable design and what is called "Life Cycle Thinking" is a complex process that must necessarily involve all players in the construction supply chain, investors with their targets, manufacturers and their commitment to decarbonization, and designers and builders with their focus on sustainable projects concepts.

In recent decades, technological development and research have led to better use of materials but also to more effective design, allowing greater performance of materials while reducing their quantities. In terms of holistic design and Life Cycle Thinking, this translates into adopting realistic assumptions about the loads to be considered in the design, finding the right trade-off between architecture and structure, avoiding oversizing of elements (and thus reducing weights), optimizing calculation and verification, and evaluating everything from a cost and emissions perspective. Even in preliminary design stages, it is essential to consider that a structure designed today may already be outdated by the time it is built, which is why it is crucial to ensure flexibility in the design of spaces, both to allow for better utilization and for future potential conversions.

All of this can be accomplished by optimizing space, using wide spans and easily adaptable and/or dismountable solutions, allowing for the reuse of structural elements.

From this broader perspective of a circular approach to design, steel proves to be an inherently circular material and a key resource in the ongoing decarbonization process. It is becoming clear design, and its impacts should always be analyzed throughout the entire life cycle, from production to end-of-life, otherwise the potential benefits of certain sustainable choices may be overlooked. For instance, consider a column initially designed in concrete that is later realized in steel.

This design choice will result in a reduction in the weight of the element; using less material will also reduce the associated CO_2 emissions. There will also be several indirect benefits, including reduced weight in the foundation (reduced material, excavation, cost), reduced incidence of transportation of structural elements (reduced CO_2 from transport, cost of transport), and reduced impact of the construction site (in terms of duration, extent, and cost). This simple example explains how without considering the project in its entirety, it is not possible to make informed choices and compare different solutions with each other. However, this example also shows how some simple considerations can get designers on the right track from very early stages of design and help them evaluate design alternatives from the perspective of sustainability.

Steel supply chain for Italian LCA database

As evidence to the commitment of the steel construction supply chain to the Life Cycle methodology, Fondazione Promozione Acciaio enthusiastically accepted the invitation to participate in the important ARCADIA project [6], developed and coordinated by ENEA and funded by the national PON Governance e Capacità Istituzionale 2014-2020 program [1]. ARCADIA's main objective is to strengthen the skills of Public Administrations to properly integrate the LCA methodology at the economic and environmental level in the definition of public procurement tenders for infrastructure and public works, as well as the implementation of green procurement. One of ARCADIA's key actions was to create a national LCA database [2] for 15 sectors, serving as a tool to promote sustainable development and circular economic initiatives.
Among the sectors identified for the creation of the LCA database is the Building-Construction sector, a strategic area for circular economy development in Europe and of primary interest to the Ministry of the Environment and Energy Security to support the application of CAM in construction, as outlined in the National Action Plan for Green Public Procurement.
Within the Building-Construction sector, several supply chains have been identified for LCA, including the steel construction sector.

Figure 3. Ceramica Sant'Agostino Vertical Self-Supporting Warehouse, Archliving (photo: Alex Filz).

Fondazione Promozione Acciaio participated in the ARCADIA project because the steel construction supply chain for steelwork is one of the main construction sectors in Italy today. The comparison in terms of million tons of steel production could be entirely "green" [9][8].
The steel construction supply chain study was conducted in collaboration with Fondazione Promozione Acciaio and the University of Brescia, Department of Civil Engineering, Architecture, Territory, Environment and Mathematics, and focused on the production of steel products for civil and industrial construction and steelwork infrastructure.
The working group identified several types of steel long products (beams, angles and hollow profiles), based on both a technical and scientific considerations (profiles complying with current European and Italian legislation and standards capable of guaranteeing adequate performance for construction) and market relevance, prioritizing the most representative products of the national production context. Arvedi Tubi Acciaio and Duferco Travi e Profilati have contributed to the implementation of the Italian LCA Data Bank of the Building- Construction sector - participating in the ARCADIA project and providing product data. Arvedi shared information on its production cycle of square and rectangular section hollow profiles used for structural applications (UNI EN 10219-1:2006, UNI EN 10219-2:2019, UNI EN 10210-1:2006 and UNI EN 10210-2:2019 standards).
Duferco providing information related to the manufacture of beams and angles always used in the construction sector (standards UNI EN 10034:1995, UNI EN 10279:2002, UNI EN 10056-2:1995).
The LCA study was conducted in accordance with ISO 14040-14044 standards, with a "cradle-to-gate" approach and using 1 kg of product as the functional unit for both types of products considered.
The results of the study obtained using the EF 3.0 impact assessment method developed by the European Commission showed that in the Climate Change category (measured as CO_2 emissions), the products have an overall impact of 0.93 $kgCO_2eq/kg$ for beams and angles and 1.6 kgCO2eq/kg for hollow profiles. These values appear to be in line with the indicative value of 1.58 $kgCO_2eq/kg$ provided by the World Steel Association organization for steel profiles [13].

Conclusion

THE TIME TO ACT IS NOW

Based on the information presented in this Position Paper, it is clear that the steel construction supply chain has long embraced the full implementation of Life Cycle Assessment (LCA). It is now taking further steps toward awareness through training and dissemination initiatives regarding the use of steel in construction, moving towards the Life Cycle Thinking. The current market situation compels us to act swiftly in this direction.

Considering the great impact that buildings have on both energy consumption and greenhouse gas emissions, steel products, within the framework of Life Cycle Thinking, are the key to making the building stock efficient, sustainable and decarbonized, both in new construction and in renovation projects. Fondazione Promozione Acciaio, along with its members, promotes the development of coherent policies to support this approach, aimed at giving full recognition to materials, such as steel, that by their nature can really contribute to the reduction of consumption and emissions in the sector and to the development of a truly circular economy: use as little as possible and reuse as much as possible.

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